Microsimulation Guidelines

Phase 1

1) Study scope and schedule
   The following information shall be included:
   a. The objective of the study
   b. The project limits
   c. The location or corridor being modeled
   d. All alternatives that will be analyzed
   e. The time of day being modeled (AM Peak, PM Peak, or Noon Peak)
   f. The resource requirements
   g. An estimated schedule to ensure that the project can be completed on time.
   h. The software and the version that will be used to develop the model
   i. Contact information
   j. Agency project number and/or federal ID number.

2) Data Collection Plan
   The following data shall be included
   a. Geometry: The basic geometric data required consist of the number of lanes, length, and free-flow speed. For intersections, the necessary geometric data may also include the designated turn lanes and their vehicle storage lengths.

   b. Traffic controls: control data consist of the locations of traffic control devices and signal-timing plans.

   c. The basic travel demand data consist of entry volumes (traffic entering the study area) and turning movements at intersections within the study area. The proportion of heavy vehicles shall also be identified in the traffic counts.

   d. Count Locations and Duration
      i. Traffic counts should be conducted at key locations within the micro simulation model study area for the duration of the proposed simulation analytical period. The counts should ideally be aggregated to no longer than 15-minute (min) time periods; however, alternative aggregations can be used if dictated by circumstances. If congestion is present at a count location (or upstream of it), care should be taken to ensure that the count measures demand and not capacity. The count period should ideally start before the onset of congestion and end after the dissipation of all congestion to ensure that all queued demand is eventually included in the count.

      ii. The counts should be conducted simultaneously if resources permit so that all count information is consistent with a single simulation period. Often, resources do not permit this for the larger simulation areas, so the analyst must establish one or more control stations where a continuous count is maintained over the length of the data collection period. The analyst then uses the control station counts to adjust the counts collected over several days into a single consistent set of counts representative of a single typical day within the study area.

3) Calibration Plan: Calibration data consist of measures of capacity, traffic counts, and measures of system performance such as travel times, speeds, delays, and queues.
   a. Field Inspection
      It is extremely valuable to observe existing operations in the field during the time period being simulated. Simple visual inspection can identify behavior not apparent in counts and floating car runs. A field inspection is also valuable for aiding the modeler in identifying potential errors in data collection.

   b. Travel Time Data
      The best source of point-to-point travel time data is "floating car runs." In this method, one or more vehicles are driven the length of the facility several times during the analytical period and the mean travel time is computed. The number of vehicle runs required to establish a mean travel time within a 95-percent confidence level depends on the variability of the travel times measured in the field. Free-flow conditions may require as few as three runs to establish a reliable mean travel time. Congested conditions may require 10 or more runs.

      The minimum number of floating car runs needed to determine the mean travel time within a desired 95-percent confidence interval depends on the width of the interval of ± 10 percent of the mean travel time. The number of required floating car runs is obtained from equation 1:

$$N=(2 * t_{0.025,N-1}\frac{s}{R})^2$$

      where:
      R = 95-percent confidence interval for the true mean
      $t_{0.025,N-1}$ = Student's t-statistic for two-sided error of 2.5 percent (totals 5 percent) with N-1degrees of freedom (for four runs, t = 3.2; for six runs, t = 2.6; for 10 runs, t = 2.3)
      s = standard deviation of the floating car runs
      N = number of required floating car runs

   c. Capacity and Saturation Flow Data
      Capacity and saturation flow data are particularly valuable calibration data since they determine when the system goes from uncongested to congested conditions: Capacity can be measured in the field on any street segment immediately downstream of a queue of vehicles. The queue should ideally last for a full hour; however, reasonable estimates of capacity can be obtained if the queue lasts only 0.5 hour (h). The analyst would simply count the vehicles passing a point on the downstream segment for 1 h (or for a lesser time period if the queue does not persist for a full hour) to obtain the segment capacity.

Saturation flow rate is defined as "the equivalent hourly rate at which previously queued vehicles can traverse an intersection approach under prevailing conditions, assuming that the green signal is available at all times and no lost times are experienced, in vehicles per hour or vehicles per hour per lane." The saturation flow rate should be measured (using procedures specified in the HCM) at all signalized intersections that are operating at or more than 90 percent of their existing capacity. At these locations, the estimation of saturation flow and, therefore, capacity will critically affect the predicted operation of the signal. Thus, it is cost-effective to accurately measure the saturation flow and, therefore, capacity at these intersections.

d. Delay and Queue Data
Comprehensive measures of intersection delay can be obtained from surveys of stopped delay on the approaches to an intersection (see the HCM for the procedure). The number of stopped cars on an approach is counted at regular intervals, such as every 30 s. The number of stopped cars multiplied by the counting interval (30 s) gives the total stopped delay. Dividing the total stopped delay by the total number of vehicles that crossed the stop line (a separate count) during the survey period gives the mean stopped delay per vehicle. The stopped delay can be converted to the control delay using the procedure in appendix A of chapter 16 in the HCM.

4) Coding Quality Assurance Plan

Quality control consists of review and error checking

The following checks of the data should be made during the data preparation step:

a. Geometric and control data should be reviewed for apparent violations of design standards and/or traffic engineering practices.

b. Internal consistency of counts should be reviewed. Upstream counts should be compared to downstream counts. Unexplained large jumps or drops in the counts should be reconciled.

c. Counts of capacity and saturation flow should be compared to the HCM estimates for these values. Large differences between field measurements and the HCM warrant double-checking the field measurements and the HCM computations.

d. Reconciliation of Traffic Counts
Inevitably, there will be traffic counts at two or more nearby adjacent locations that do not match. This may be a result of counting errors, counting on different days (counts typically vary by 10 percent or more on a daily basis), major traffic sources (or sinks) between the two locations, or queuing between the two locations. In the case of a freeway, a discrepancy between the total traffic entering the freeway and the total exiting it may be caused by storage or discharge of some of the vehicles in growing or shrinking queues on the freeway.

The analyst must review the counts and determine (based on local knowledge and field observations) the probable causes of the discrepancies. Counting errors and counts made on different days are treated differently than counting differences caused by midblock sources/sinks or midblock queuing.

Discrepancies in the counts resulting from counting errors or counts made on different days must be reconciled before proceeding to the model development task. Inconsistent counts make error checking and model calibration much more difficult. Differing counts for the same location should be normalized or averaged assuming that they are reasonable. This is especially true for entry volumes into the model network. Intersection turning volumes should be expressed as percentages based on an average of the counts observed for that location. This will greatly assist with calibrating the model later.

Differences in counts caused by midblock sources (such as a parking lot) need not be reconciled; however, they must be dealt with by coding midblock sources and sinks in the simulation model during the model development task.

Differences in entering and exiting counts that are caused by queuing in between the two count locations suggest that the analyst should extend the count period to ensure that all demand is included in both counts.

Accurate vehicle classification counts and accurate travel speeds can also affect the traffic volumes. Trucks and other large vehicles and inaccurate speeds can skew the volume counts.

e. Error checking includes:

i. Review inputs

A checklist for verifying the accuracy of the coded input data is provided below:

1. Link and node network:
    - Check basic network connectivity (are all connections present?).
    - Check link geometry (lengths, number of lanes, free-flow speed, facility type, etc.).
    - Check intersection controls (control type, control data).
    - Check for prohibited turns, lane closures, and lane restrictions at the intersections and on the links.

2. Demand:
    - Check vehicle mix proportions at each entry node/gate/zone.
    - Check identified sources and sinks (zones) for traffic.
    - Verify zone volumes against traffic counts.
    - Check vehicle occupancy distribution (if modeling HOVs).
    - Check turn percentages (if appropriate).

- Check O-Ds of trips on the network.

3. Traveler behavior and vehicle characteristics:
    - Check and revise, as necessary, the default vehicle types and dimensions.
    - Check and revise the default vehicle performance specifications.

ii. Review Animation

Animation output enables the analyst to see the vehicle behavior that is being modeled and assess the reasonableness of the microsimulation model itself. Running the simulation model and reviewing the animation, even with artificial demands, can be useful to identify input coding errors. The analyst inputs a very low level of demand and then follows individual vehicles through the network. Aberrant vehicle behavior (such as unexpected braking or stops) is a quick indicator of possible coding errors.

A two-stage process can be followed in reviewing the animation output:

1. Run the animation at an extremely low demand level (so low that there is no congestion). The analyst should then trace single vehicles through the network and see where they unexpectedly slow down. These will usually be locations of minor network coding errors that disturb the movement of vehicles over the link or through the node. This test should be repeated for several different O-D zone pairs.

2. Once the extremely low demand level tests have been completed, then run the simulation at 50 percent of the existing demand level. At this level, demand is usually not yet high enough to cause congestion. If congestion appears, it may be the result of some more subtle coding errors that affect the distribution of vehicles across lanes or their headways. Check entry and exit link flows to verify that all demand is being correctly loaded and moved through the network.

The animation should be observed in close detail at key congestion points to determine if the animated vehicle behavior is realistic.

<u>Phase 2</u>

5) Data Collection Results Report

The following information should be included in the data collection report.

a. Desired Speed Distributions

b. Driver Behavior parameters.

c. Link types including the associated vehicle class and driver behavior set.

d. Traffic Compositions

e. Signal Controllers

f. Describe each controller type and the associated files. Provide signal timing plans in a screen shot or by inclusion of the .vap file. Provide the source and date of the signal timing data used to describe the model signal controllers.

g. Background Image

h. Links/Connectors (Identify any data used to define unique geometry elements in the model, including lane closures, grade information, and lane change information).

i. Lane Assignments

j. Traffic Volumes (Describe vehicle input locations and volume data. Include the source and date of the information).

k. Routes and Relative Flow

l. Desired Speed Decisions (Describe the locations of desired speed regions and define the associated speed profiles and their rationale).

m. Reduced Speed Areas (Describe the locations of reduced speed areas and define the associated speed profiles and their rationale).

n. Priority Rules for Non-Signalized Intersections

   Describe the locations of non-signalized intersections. Also define the level of detail of the priority rules, as follows:

   i. Basic: Minimum required right-of-way (ROW) rules were implemented for vehicle traffic and pedestrian movements

   ii. Advanced: Additional conditions are modeled (e.g., such as oversaturated conditions)

   iii. Other: Other comments on the priority rules, including elements not modeled, such as “no pedestrian priority rules”

   iv. Car/truck headways and gap time settings

o. Stop Signs for Non-Signalized Intersections

p. Roundabouts (Describe locations and clarify priority rules—particularly gap acceptance)

q. Signal Heads (Describe locations)

r. Detectors (Describe locations, as well as the source and date of data used to define detector locations).

s. Stop Signs for RTOR (Describe locations)

t. Priority Rules for Signalized Intersections

Describe the locations of signalized intersections. Also define the level of detail of the priority rules, as follows:

i. Basic: Minimum required rules were implemented for vehicle traffic and pedestrian movements

ii. Advanced: Additional conditions were modeled (e.g., such as oversaturated conditions)

iii. Other: Other comments on the priority rules, including elements not modeled such as "no pedestrian priority rules"

iv. Car/truck headways and gap time settings

6) 50% coded model to check model development
   a. Coded roadway network
   b. Coded traffic control devices
   c. Coded traffic demand data

<u>Phase 3</u>

7) 100% coded model for error checking
   a. Routing decisions
   b. Adjustment of default simulation parameters (driving behavior, gap acceptance, and etc.)
   c. Priority rules
   d. Output file selections and settings

8) Calibration test results report
   TRB Paper 04-3981 (Session 262)
   Guidelines for Calibration of Microsimulation Models: Framework and Applications

Phase 4

9) Alternatives analysis report
   a. Baseline demand forecast
      Forecasts of future travel demand are best obtained from a travel demand model. These models require a great deal of effort and time to develop and calibrate. If one does not already exist, then the analyst may seek to develop demand forecasts based on historic growth rates. A trend-line forecast might be made, assuming that the recent percentage of growth in traffic will continue in the future. These trend-line forecasts are most reliable for relatively short periods of time (5 years or less). They do not take into account the potential of future capacity constraints to restrict the growth of future demand. Additional information and background regarding the development of traffic data for use in highway planning and design may be found in National Cooperative Highway Research Program (NCHRP) Report 255, *Highway Traffic Data for Urbanized Area Project Planning and Design.*

   b. Generation of Project Alternatives for Analysis
      i. Performing a microsimulation analysis of the baseline demand forecast to identify the deficiencies.
      ii. Identifying alternative improvements that solve one or more of the identified problems.

   c. Selection of Measures of Effectiveness (MOEs)
      MOEs are the system performance statistics that best characterize the degree to which a particular alternative meets the project objectives (which were determined in the Project Scope task). Thus, the appropriate MOEs are determined by the project objectives and agency performance standards rather than what is produced by the model.

   d. Model Application (Runs).
      Microsimulation models rely on random numbers to generate vehicles, select their destination and route, and determine their behavior as they move through the network.

      No single simulation run can be expected to reflect any specific field condition. The results from individual runs can vary by 25 percent and higher standard deviations may be expected for facilities operating at or near capacity. It is necessary to run the model several times with different random number seeds to get the necessary output to determine mean, minimum, and maximum values.

   e. Tabulation of Results.
      Microsimulation models typically produce two types of output: (1) animation displays and (2) numerical output in text files. The animation display shows the movement of individual vehicles through the network over the simulation period. Text files report

accumulated statistics on the performance of the network. It is crucial that the analyst reviews both numerical and animation output (not just one or the other) to gain a complete picture of the results. This information can then be formatted for inclusion in the final report.

f. Evaluation of Alternatives.
This step involves the evaluation of alternatives using the microsimulation model results. First, the interpretation of system performance results is discussed. Then, various analyses are discussed for assessing the robustness of the results. The ranking of alternatives and cost-effectiveness analyses need to be documented.

10) Final Report

The final report presents the assumptions, analytical steps, and results of the analysis in sufficient detail for decision makers to understand the basis for and implications of choosing among the project alternatives. The final report, however, will not usually contain sufficiently detailed information to enable other analysts to reproduce the results. That is the purpose of the technical report/appendix.

The effort involved in summarization of the results should not be underestimated, since microsimulation models produce a wealth of numerical output that must be tabulated and summarized. The final report should include the following:

a. Study objectives and scope
b. Study approach (tools, rationale)
c. Data collection
d. Calibration tests and results
e. Baseline forecast assumptions
f. Description of alternatives
g. Results

11) Technical documentation
The technical report/appendix documents the microsimulation analysis in sufficient detail to enable an analyst to reproduce the results (the version or release of the software used is included). It may be an appendix to the final report or a separate document.

The technical report/appendix is a vital step in preserving the rationale for the various decisions that were made in the process of developing, calibrating, and operating a microsimulation model. The documentation should be sufficient so that given the same input files, another analyst can understand the calibration process and repeat the alternatives analysis.

The technical report/appendix should include the model input and output files (in electronic format) for the final model calibration run and alternatives analysis model runs.

In addition to a diskette with the calibration and alternatives analysis files (input and output), the technical report/appendix should include a printed listing of the files on the diskette with a text description of the contents and purpose of each file.